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Scientific and Quantitative Literacy and Its Influence on Academic Achievement in Physical Science

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Abstract. Many students found Physical Science to be a particularly challenging subject despite its recognized importance. Thus, this study aimed to assess the levels of scientific literacy (SL), quantitative literacy skills (QLS), and academic achievement in Physical Science (AAP) among Grade 12 students. The study also investigated the relationships among these variables. The respondents were 231 Grade 12 students selected through stratified random sampling. The study is utilizing a researcher-made questionnaire to gather data on the academic achievement in Physical Science, and adapted questionnaires to measure scientific and quantitative literacy. The collected data were analyzed using mean, standard deviation, and spearman rank-order. Meanwhile, the researcher abided to the Philippine Health Research Ethics Board (PHREB). Results indicated developing interpretation of scientific literacy and quantitative literacy skills among the students, whereas results in terms of Physical Science academic achievement were interpreted at the approaching proficiency level. Significant positive correlations were found between both scientific and quantitative literacy and academic achievement in Physical Science. Thus, the study validated Jean Piaget's Constructivist Learning Theory and John Dewey's Progressive Education. With these, future studies may conduct more in-depth analyses using a mixed-method design to further explore the factors influencing students' academic achievement in Physical Science.

Keywords. Physical Science, Scientific Literacy, Quantitative Literacy, Academic Achievement, Descriptive-correlational, Philippines

1. Introduction

Physical science systematically studies the inorganic world, separate from the organic field under biological science [5]. It is typically divided into four main areas: astronomy, physics, chemistry, and Earth sciences [26]. According to Jena (2021) [17], the primary goal of integrating Physical Science into the educational curriculum is to equip students with problem-solving abilities and critical thinking skills that are universally useful. These essential life skills enable students to generate new ideas and make intelligent decisions. Similarly, scientific literacy plays a vital role in enhancing students' ability to understand complex concepts in Physical Science. As Oladejo et al. (2023) [25] mentions, developing scientific literacy helps students grasp abstract and challenging ideas within the subject.

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The development of scientific literacy directly supports achievement in Physical Science, as it enables students to apply relevant skills in practical contexts such as understanding nature, addressing environmental issues, and developing innovative solutions to improve quality of life [12]. Scientific literacy (SL), as Costa (2021) [7] explains, encompasses not only an understanding of scientific content but also an appreciation of the nature of science and its impact on society. In addition to scientific literacy is the quantitative literacy which involves using mathematical concepts in everyday situations and having a basic understanding of numbers [21]. In these times where data significantly influences daily life and professional development, it is widely acknowledged that having a grasp of quantitative literacy is important, in staying well informed and reaching professional goals [41]. Thus, combining quantitative and scientific literacy is crucial to effectively address problems and issues in the field of physical science [1].

Scientific and quantitative literacy skills are keys for the success in Physical Science, particularly Physics, making them essential prerequisites [6, 14, 45]. Scientific literacy is necessary for students, enabling them to apply scientific knowledge to solve daily problems and make informed decisions about the world, highlighting the need for science education that promotes this skill as doing so can lead to better learning outcomes for students [18]. Moreover, one branch of Physical Science, Physics, is mathematical in nature and thus requires quantitative literacy skills in which students must be proficient in solving worded problems [25, Wider & Wider, 2023). Subsequently, Uzpen et al. (2019) [45] suggested that building on students' quantitative literacy skills is essential for enhancing their scientific literacy, which in turn is needed for students to improve their academic achievement in physical science.

In the Philippine Basic Education system, all non-STEM students are required to take Physical Science, which includes topics like matter, motion, electricity, magnetism, light, and the universe [32]. However, the complexity of these topics may be overwhelming for senior high school students with Physics being particularly challenging making it difficult for the Department of Education to improve the academic achievement in this area [28, 43]. The 2019 Trends in International Mathematics and Science Study (TIMSS) ranked the Philippines last out of 58 countries, with a science score of 249. Similarly, the 2022 Program for International Student Assessment (PISA) showed Filipino students scoring 355 in science marking a slight decline from 2018, where the country ranked 79th out of 81 countries [24, 42]. In addition, teachers observed that students struggle in Physical science in the local context, particularly in regional assessments. These concerning results have led the Department of Education to take essential steps to investigate the underlying causes and factors contributing to the issue.

Numerous studies on students' academic achievement in Physical Science have been conducted in the Philippines, focusing on different educational levels: senior high school [9, 27, 28], junior high school [2, 37, 43, 47].These studies examine Physical Science achievement concerning scientific literacy [18, 20, 22, 38, 45]; quantitative literacy, numeracy, mathematics achievement, or problem-solving skills [6, 45, 46, 48, 49]. However, few studies in the Philippines have examined the links between scientific or quantitative literacy and Physical Science achievement.

Thus, this study aimed to assess the level of Grade 12 students' scientific literacy, quantitative literacy, and academic achievement in Physical Science. Furthermore, this study investigated the relationships between scientific literacy, quantitative literacy skills, and academic achievement in Physical Science in a medium-sized schools division in a component city in Negros Island Region during the school year 2024-2025. The results of the study served as a basis for the formulation of supplementary activity sheets that integrated scientific and

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quantitative literacy to address the declining academic performance of students in physical science.

2. Framework of the Study

This study conjectures that students' achievement in Physical Science as being influenced by their scientific literacy (SL) and quantitative literacy skills (QLS). Using the constructivist learning theory as a foundation, it recognizes that students learn best when they connect new Physical Science concepts to what they already know. Building strong SL and QLS helps them better understand complex topics that require reasoning and problem-solving. The progressive education theory also supports this idea by encouraging real-life, hands-on learning experiences where students can apply what they've learned, test their ideas, and reflect on the results. Through these approaches, students not only gain a deeper understanding of Physical Science but also develop the confidence and skills needed to perform better academically.

3. Methodology

This study used a quantitative research design, specifically the descriptive-correlational perspectives. The descriptive approach assessed the level of SL, QLS, and AAP of the students. On the other hand, the correlational perspective assessed the relationship between SL and AAP, and QLS and AAP. The respondents of the study were 231 students who are enrolled in ABM, GAS, HUMSS, Cookery, EIM, SMAW, and Tailoring strand in a medium-sized school division within a component city in the Negros Island Region for the second semester of the 2024-2025 school year, which were selected using stratified random sampling, with the number of respondents determined using Raosoft.

To assess the students' scientific and quantitative literacy skills, the researcher utilized a standardized assessment tool from Lawson (2000) [31] and Gaze (2014) [11], respectively. On the other hand, to assess the academic achievement of students in physical science based on Most Essential Learning Competencies (MELCs), a researcher-made instrument was utilized in the study. The internal consistency of the students' scores was assessed using the Kuder-Richardson Formula 20 (KR-20). The resulting coefficients was 0.716 for SL, 0.718 for QLS, and 0.765 for AAP. Furthermore, the researcher-made instrument undergone Lawshe's (1975) Content Validity Ratio (CVR), verified by a panel of ten experts in the field with the overall validity score was 4.77, with a Content Validity Index (CVI) of 0.92. The data were all interpreted using the scale of interpretation: Beginning, Developing, Approaching Proficiency, Proficient, and Advanced.

Descriptive-correlational analysis was utilized to analyze the data gathered. The descriptive analysis was used in profiling the respondents and assessing the level of SL, QLS, and AAP of the students, specifically the mean, standard deviation, frequency count, and percentage distribution. Furthermore, since the distributions of the data of the variables failed in normality, this necessitated the usages of non-parametric tests for further statistical analyses. As a result, the researcher used the Spearman rank-order in the correlational analysis. The correlational analysis measured the correlation between SL and the AAP of the students, and QLS and the AAP of the students.

Lastly, the researcher followed the rules of the Philippine Health Research Ethics Board (PHREB) to ensure that the study was conducted ethically, respected people's rights, aimed to do good, and treated everyone fairly.

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4. Results and Discussion

4.1.1.1 Demographic Profile of the Respondents.

Table 1 presents the demographic profile of the respondents. In terms of sex, 60.2% (n=139) of the respondents were female, while 39.8% (n=92) were male, totaling 231 students. This indicates that there is a notable sex imbalance, with females representing significantly larger portion of the sample population.

The disparity in the distribution reflects the actual enrollment trend in the public senior high schools within the locality. Previous national and local data on secondary education often show higher female participation rates in certain academic tracks or public-school settings, particularly in science-related programs or schools with a strong academic orientation. This pattern could be attributed to several socio-cultural factors, such as higher female academic persistence, differences in educational motivation, or even gendered expectations from families and communities.

Table 2
Demographic Profile of the Respondents

Variable	N	%
Sex		
Male	92	39.8
Female	139	60.2
Total	231	100.0

4.1.2. Level of Scientific Literacy of Students

Table 2 presents the level of scientific literacy of the students, revealing that the overall mean score was 7.67 (SD=3.08), interpreted as Developing. When grouped according to sex, both male (M=7.45, SD=2.93) and female (M=7.81, SD=3.17) students exhibited a Developing level of scientific literacy.

The findings show that students have developing scientific literacy, they possess basic knowledge and skills but still need support in completing tasks. This suggests that students have not yet fully mastered formal, concrete, and early formal reasoning skills assessed, likely due to their lack of necessary foundational knowledge and skills appropriate for their level. In addition, their prior learning experience may be an underlying factor, as they might not have engaged in in-depth critical thinking and reasoning during earlier stages of their development. Moreover, another possible factor is the spiral curriculum, which may hinder continuous learning and knowledge acquisition because it lacks sustained focus on specific subfields of science.

Congruent with these findings is the study by Setyowati et al. (2022) [39] on students' poor scientific literacy, which attributes the issue to their lack of continuous engagement in the learning process. In addition, even with the implementation of the spiral progression approach, students' overall performance when it comes to science remained below the satisfactory level, indicating that their understanding and application of scientific concepts still need further improvement [4]. A study conducted by Fernando et al. (2024) [8] suggest that applying what students have learned, as well as deepening their understanding of the subject matter, can help them grasp scientific concepts more thoroughly. In addition, Queiruga-Dios et al. (2020) [34] states that scientific literacy involves not only the possession of key scientific knowledge, but also in understanding the relationships between them. The

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existence of process of scientific discovery, comprehension, and scientific reasoning cause struggle in attaining the high level of scientific literacy.

Table 3
Level of Scientific Literacy of Students

Variable	M	SD	Interpretation
Sex			
Male	7.45	2.93	Developing
Female	7.81	3.17	Developing
Whole	7.67	3.08	Developing

4.1.3. Level of Quantitative Literacy Skills of Students

Table 3 presents the level of Quantitative Literacy Skills. As a whole, students demonstrated a Developing level (M=6.32, SD=3.11). Correspondingly, when grouped by sex, both male (M=5.70, SD=2.66) and female (M=6.74, SD=3.32) students exhibited a Developing level of quantitative literacy skills.

The findings show that respondents from the selected school demonstrated only a developing level of achievement on the Quantitative Literacy Skills test, they possess basic knowledge and skills but still need support in completing tasks. This concerning result may suggest that students' prior knowledge was not fully developed due to the spiral curriculum's limited and inconsistent focus on these skills. Another possible explanation is related to students' cognitive development since mathematics requires higher-order thinking and problem-solving skills, not just memorization or surface-level understanding of concepts.

The finding is backed up by the study conducted by Rakhmawati and Mustadi (2021) [35], which found that students' quantitative literacy skills remain low and may fall significantly short of the expected standard. Moreover, Azid et al., 2022 [3] highlighted that logical reasoning and extensive reading improve problem-solving, while visual representations can enhance comprehension and accuracy [33]. Furthermore, foundational mathematical knowledge and reasoning skills are also crucial for understanding advanced concepts [16].

Table 3
Level of Quantitative Literacy Skills

Variable	M	SD	Interpretation
Sex			
Male	5.70	2.66	Developing
Female	6.74	3.32	Developing
Whole	6.32	3.11	Developing

4.1.4. Level of Academic Achievement in Physical Science

Table 4 presents the level of Academic Achievement in Physical Science of students. As a whole, the students were at the Approaching Proficiency level (M=20.60, SD=9.47). Likewise, when grouped according to sex, male students (M=18.10, SD=8.15) showed a Developing level, whereas female students (M=22.26, SD=9.93) reached the Approaching Proficiency level.

The findings indicate that respondents from the selected school demonstrated an Approaching Proficiency level of achievement on the Physical Science Achievement Test, which suggests that students have acquired or are developing fundamental knowledge, skills,

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and core understanding of physical science, with only little guidance needed from teachers and peers. This difficulty may stem from teaching strategies that focus too heavily on memorization rather than on applying lessons in meaningful ways. Additionally, weak foundational literacy skills, such as SL and QLS that may limit students' ability to comprehend and analyze scientific concepts. Furthermore, some students may find complex topics particularly challenging, which hinders their ability to achieve full mastery of the subject. Likewise, in terms of sex, female scored higher level compared to male. The reason might be that female students often exhibit more positive attitude towards studying, and may outperform males in the academic settings, especially in situations that require diligence, consistency, and sustained effort.

This result is supported by the study conducted by Mzobe and Chinaka (2024) [23], which states that despite its importance, many learners lack a solid understanding of fundamental concepts in physical science. In addition, the subject's high level of complexity and abstract nature makes it particularly difficult for secondary school students to comprehend [13, 40]. Panergayo (2023) [27] similarly acknowledged physical science as one of the most demanding subjects, encompassing complex fields such as physics, chemistry, and astronomy. Furthermore, Oladejo et al. (2023) [25] emphasized that the mathematical and abstract elements of physics contribute to students' perception of physical science as a challenging subject. In addition, Khan et al., (2024) [19] concluded that academic achievement in physical science goes beyond mere memorization but it also depends on applying concepts and solving problems and found that male students performed lower than female students in the subject.

Table 4
Level of Academic Achievement in Physical Science

Variable	M	SD	Interpretation
Sex			
Male	18.10	8.15	Developing
Female	22.26	9.93	Approaching Proficiency
Whole	20.60	9.47	Approaching Proficiency

4.1.5. Relationship between Scientific Literacy and Academic Achievement in Physical Science

Table 5 shows that the results revealed a significant correlation between scientific literacy and academic achievement in Physical Science, [rs (229)=0.640, p=0.000] of Grade 12 public senior high school students under the school year 2024-2025.

The results show that the respondents' level of scientific literacy is a contributing factor to their academic achievement in physical science. The findings suggest a significant correlation between higher levels of scientific literacy and improved academic performance in physical science. In addition, the result implies that students who comprehend scientific data, can analyze and interpret findings in the experiment, and those who can think critically about scientific problems are more likely to succeed in their academic achievement in Physical Science.

Moreover, Khan et al. (2024) [19] suggests that students with stronger conceptual knowledge tend to achieve higher scores in physical science. Additionally, learners should be allowed to perform learning tasks within environments that are both relevant and realistic to their experiences. Moreover, Paristiowati et al. (2019) [29] concluded that students with strong scientific literacy skills are proficient in identifying scientific elements in complex scenarios. These are further validated by the research findings of Pasigon (2024) [30], confirming that

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students' understanding of the basic and complex concepts in the subject is influenced by their scientific literacy.

Table 5
Relationship between Scientific Literacy and Academic Achievement in Physical Science

Variable	r_s	df	p
Scientific Literacy and Academic Achievement in Physical Science	0.640*	229	0.000

Note: *correlation is significant when p≤0.05

4.1.6. Relationship between Quantitative Literacy Skills and Academic Achievement in Physical Science

Table 6 shows that there is a significant positive correlation between quantitative literacy skills and academic achievement in Physical Science, [rs (229) =0.565, p=0.000]. These findings suggest that the level of quantitative literacy is associated with performance in Physical Science.

The results indicate that the respondents' level of quantitative literacy is a significant factor influencing their academic performance in physical science. The finding implies that QLS is a contributing factor, especially in topics in Physical Science that requires mathematical understanding and computation. The results also highlight the importance of prior mathematical knowledge in achieving success in Physical Science. Students who lack basic numerical skills may struggle to fully comprehend scientific understanding that are quantitative in nature, potentially hindering their academic progress in the subject. Furthermore, this suggests that that there is a need to integrate QLS in the classes, reinforce problem-solving strategies and quantitative proficiency. In addition, providing real-world quantitative problems, and incorporating contextualized mathematics in scientific instruction.

This is supported with the research conducted by Tong et al. (2024) [44] which encouraged students to focus on strengthening their mathematical skills, since mastering these competencies leads to better academic achievement. Similarly, Wider and Wider (2023) [48] found a significant positive relationship between students' quantitative literacy skills and their academic performance in physics, a branch of physical science. This connection likely stems from the mathematical nature of the subject, which demands strong skills in solving word problems [25]. Furthermore, lack of fundamental knowledge in mathematics has been shown to significantly delay students' ability to grasp and apply key Physics concepts [10, 15]. This suggests that difficulties in Physics learning may not solely stem from the complexity of the subject itself, but rather from insufficient mathematical preparation. Backed up Burkholder et al. (2021), the present study reinforces the idea that a solid foundation in mathematics is perhaps the most influential factor in fostering students' academic achievement in Physics. Likewise, previous studies have underscored the importance of foundational quantitative literacy skills for success in other science disciplines [36, 46].

Table 6
Relationship between Quantitative Literacy Skills and Academic Achievement in Physical Science

Variable	r_s	df	p
Quantitative Literacy Skills and Academic Achievement in Physical Science	0.565*	229	0.000

Note: *correlation is significant when p≤0.05

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This study validated Jean Piaget's Constructivist Learning Theory which emphasizes that new knowledge is constructed by building upon existing knowledge, highlighting the importance of linking new information to prior understanding for conceptual change [19]. It also established support to John Dewey's theory of progressive education which highlights socially interactive learning experiences that are developmentally appropriate for students. The findings implied that proficiency in both scientific literacy and quantitative literacy skills are needed before studying new information, particularly when dealing with subjects such as Physical Science that build upon this foundational literacy.

Moreover, the results emphasized that to enhance academic achievement in the subject, education should be student-centered, focusing on real-world problem-solving, critical thinking, and promoting active learning.

5. Conclusion

The findings of the study highlight that scientific literacy and quantitative literacy skills are contributing factors to the academic achievement of students in Physical Science. These correlations suggest that students with stronger competencies in scientific literacy and mathematical skills tend to perform better in the subject. Furthermore, the study underscores the important role of SL and QLS in the academic achievement of students, since mastery of content alone is not enough; students must also possess the abilities to interpret, analyze, apply, and solve scientific principles. However, the results for both SL and QLS were only at the "Developing" level among most students, which indicates that this level limits their potential to fully achieve success in the subject. As such, enhancing students' literacy in these areas may be a crucial step toward improving their overall academic achievement in science education.

6. Limitations of the Findings

This study considers several limitations. First, the scope of the population is limited, as it focuses only on public senior high school students. As a result, the findings may not be fully representative of private school students, which may limit the generalizability of the results in assessing levels of SL, QLS, and PSAT.

Second, the student behavior factors such as test anxiety, unfamiliarity of the test construction, and external distractions that may have affected the performance of students during the test, which may potentially lead to results that do not accurately reflect their actual abilities.

The study's cross-sectional design, conducted over a brief two-week period with one-hour tests for each assessment, limits its ability to capture changes or improvements in students' scientific and quantitative literacy over time.

Lastly, the assessment tool used in the study presents a limitation for it is a teacher-made questionnaire based on MELCs, as some students may not have been taught all relevant topics due to school activities, potentially affecting their performance and the accuracy of the results.

7. Practical Value of the Paper

The practical value of this study lies in its potential to suggest to the curriculum design and teaching strategies in Physical Science. By emphasizing the development of scientific and quantitative literacy, educators, institutions, and the Department of Education can implement interventions—such as supplementary activity sheets—to enhance students' literacy. This underscores the potential to enhance academic outcomes and better equip students for future success in science-related fields and careers.

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8. Direction for Future Research

Future research should include a more diverse sample by incorporating students from both public and private schools across different schools and divisions. This would improve the generalizability of the findings and provide a more comprehensive view of literacy levels among senior high school students. Additionally, future researchers should investigate the influence of affective and behavioural factors, the roles of socio-economic status, parental educational attainment, social interactions and institutional factors in shaping the scientific literacy and quantitative literacy skills of the students could provide a more comprehensive understanding that informs more inclusive and equitable educational practices.

Moreover, longitudinal studies tracking the sustained impact of early literacy skills on the academic performance as students' progress through different academic stages and across science disciplines are also recommended. Future studies could also examine the effectiveness and scalability of these interventions across diverse educational settings, contributing to the broader development of literacy skills and student performance. Furthermore, future researchers may investigate the teaching strategies, learning environments, and the way these foundational literacies are integrated in the lessons, which may help sharpen students' scientific literacy and quantitative literacy skills.

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